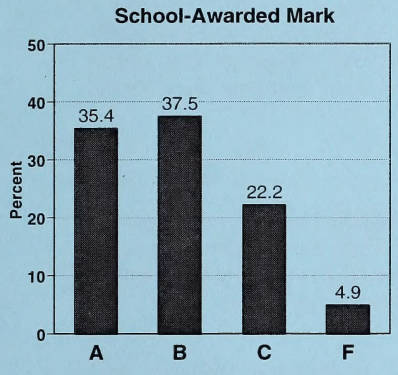
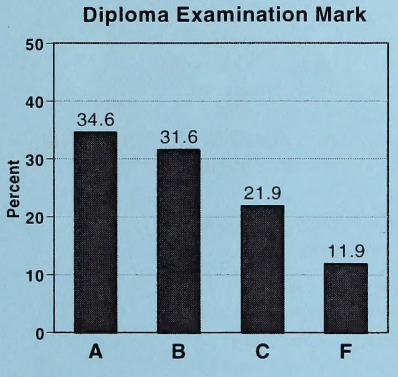
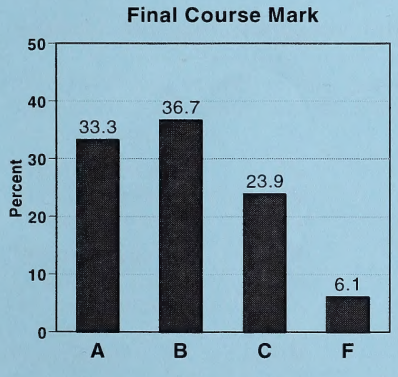
Physics 30

Diploma Examination Results
Examiners' Report for June 1999







The summary information in this report provides teachers, school administrators, and students with an overview of results from the June 1999 administration of the Physics 30 Diploma Examination. This information is most helpful when used in conjunction with the detailed school and jurisdiction reports that are provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined January, June, and August results is made available annually.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 53%, 12 numerical-response questions worth 17%, and two written-response questions worth 30% of the total examination.

Achievement of Standards

The information reported below is based on the final course marks achieved by 5 666 students in Alberta who wrote the June 1999 examination and received a school-awarded mark.

- 93.9% of the 5 666 students achieved the *acceptable standard* (a final course mark of 50% or higher).
- 33.3% of the 5 666 students achieved the *standard of excellence* (a final course mark of 80% or higher).

Students continue to demonstrate strong skills in addressing most aspects of the written-response questions. Students are willing to apply the knowledge and skills learned in Physics 30 to answer these questions. Very few students did not respond to the written-response questions. Students continue to have difficulty in clearly communicating their understanding of the physics principles used to solve the question.

Students must pay particular attention to recording their answers to numerical-response questions correctly. In particular, students must ensure that they record their response in the required format and that they record the correct number of digits. Students' attention should be directed to the numerical-response examples provided on the instruction pages for the Physics 30 Diploma Examination.

Approximately 36.6% of the students who wrote the examination were female. Of these, about 95.4% achieved the *acceptable standard* for a final course mark, compared with 93.1% of the male students. Approximately 33.0% of the female students achieved the *standard of excellence*, compared with 33.4% of male students. The average examination mark achieved by the female students was 70.3%, and the male students achieved an average mark of 70.4%.

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Provincial Averages

- The average school-awarded mark was 72.4%.
- The average diploma examination mark was 70.4%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 71.7%.

Approximately 5.6% of the students who wrote the examination in June 1999 and received a school-awarded mark had previously written at least one other Physics 30 Diploma Examination during the June 1998 to June 1999 period. This subpopulation (320) achieved an examination average of 62.7%, compared with 70.7% for the population (5 400) who first wrote the Physics 30 examination in June 1999. The group of students who rewrote increased their examination score on average by 11.5%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the *acceptable standard* will obtain a mark of 50% or higher, and students achieving the *standard of excellence* will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score (out of 1) achieved by students who wrote the examination.

Questions are also classified by general learner expectations (GLE). Even though some questions address more than one GLE, only one GLE was selected for the purpose of this report.

Knowledge:

GLE 1 Explain gravitational, electrical, and magnetic effects on systems

GLE 2 Analyze and predict the behaviour and physical interactions of objects

GLE 3 Describe and analyze resistive circuits and the function of electromagnetic devices

GLE 4 Solve problems related to electromagnetic wave behaviour and the atomic theory

Skills:

SPC Scientific Process Skills & Communication Skills

Science, Technology, Society:

STS Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPC	STS
MC1	A	0.728	✓					
MC2	B	0.723		✓				✓
NR1*	1.94	0.739		✓				✓
MC3	A	0.813		✓				
MC4	B	0.679	✓				✓	
MC5	D	0.737	✓				✓	
MC6	D	0.612		✓			✓	
MC7	A	0.723		✓			✓	
MC8	C	0.815	✓					
MC9	A	0.865	✓					
MC10	C	0.798		✓				✓
MC11	B	0.540		✓			✓	✓
MC12	D	0.692		✓				
MC13	C	0.782		✓			✓	
MC14	B	0.696				✓		
NR2	8.27	0.716	✓					
MC15	B	0.566	✓					

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPC	STS
NR3	7.78	0.881				✓		
MC16	C	0.808				✓		
MC17	D	0.726				✓		
MC18	C	0.421				✓		
MC19	C	0.394			✓			✓
MC20	D	0.728		✓			✓	
NR4	1.67	0.886		✓				✓
MC21	B	0.690	✓				✓	
NR5	7.19	0.483		✓				✓
MC22	A	0.705		✓				
NR6†	1201	0.574				✓		
MC23	C	0.478		✓			✓	
MC24	C	0.804			✓			
MC25	A	0.720		✓				
MC26	C	0.597		✓				✓
MC27	B	0.635		✓				✓
NR7	3014	0.813				✓		✓
MC28	C	0.822				✓		✓
MC29	A	0.685				✓		✓
MC30	D	0.702				✓		
NR8	7319	0.906				✓		
MC31	D	0.695		✓				
NR9	1819	0.897				✓	✓	
MC32	B	0.855				✓		✓
MC33	A	0.681				✓		✓
NR10	2.28	0.865		✓				✓
MC34	D	0.693				✓	✓	
NR11	3.0	0.647				✓	✓	
MC35	B	0.716				✓	✓	
MC36	C	0.408				✓		
NR12	9237	0.689				✓		
MC37	B	0.691				✓		
WR1	—				✓ (15)		✓ (5)	✓ (15)
WR2	—			✓ (15)			✓ (5)	✓ (15)

*NR1: 1.37 if A was selected from MC2; 1.94 if B was selected; 91.0 or 91.1 if C was selected; and, 182 if D was selected
†NR6: 1201 if A was selected from MC22; 5132 if B was selected; 4966 if C was selected; and, 9109 if D was selected

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, bear in mind that subtest results **cannot** be directly compared. Results are in average scores.

Machine Scored	70.4%
Multiple choice	68.7%
Numerical response	75.8%
Written Response	70.0%*
Question 1	79.4%
Communication	86.0%
Content	75.5%
Question 2	60.2%

* Individual student scores for Question 1 and Question 2 are each weighted 15% of the total exam.

Average Percentage Scores and Total Test Weighting in Percentage by General Learner Expectation

		Average	*Weighting*
GLE 1	Explain gravitational, electrical, and magnetic effects on systems	72.5%	11.4%
GLE 2	Analyze and predict the behaviour and physical interactions of objects	66.3%	42.1%
GLE 3	Describe and analyze resistive circuits and the function of EM devices	76.1%	17.9%
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	71.5%	28.6%
SPC	Scientific Process Skills & Communication Skills	69.0%	28.6%
STS	Connections Among Science, Technology, & Society	70.0%	51.4%

Multiple-Choice and Numerical-Response Questions

The following table gives results for four questions selected from the examination and shows the percentage of students in four groups that answered the question correctly. The comments following the table relate to some of the understandings and skills the students may have used to answer these questions.

Percentage of Students Correctly Answering Selected Machine-Scored Questions

	Question Number			
Student Group	**MC 18**	**MC 22**	**NR 6**	**MC 33**
All Students	42.1	70.5	57.4	68.1
Students achieving the *standard of excellence* (80% or higher, or A) on the whole examination	66.1	92.5	89.3	79.8
Students achieving the *acceptable standard* but not the *standard of excellence* on the whole examination	32.1	64.3	47.7	64.2
Students who have not achieved the *acceptable standard* (49% or less, or F) on the whole examination	17.8	35.0	8.6	51.9

18. Electromagnetic radiation is produced by charged particles that are moving

A. at the speed of light
B. with zero acceleration
***C.** with a changing velocity
D. parallel to a fixed magnetic field

Multiple-choice question 18 Most students who achieved the *standard of excellence* on the examination correctly answered this question. To answer correctly, students had to recognize that electromagnetic radiation is produced by accelerated charged particles. Alternative A was the most frequent distractor chosen by students. These students incorrectly assumed that since electromagnetic radiation travels at the speed of light, so does the charged particle producing the radiation. It is likely that alternative D was chosen by students who recognized that electromagnetic radiation is propagated by magnetic and electric fields. However, a charged particle is not affected by a uniform magnetic field directed parallel to its motion.

Use the following information to answer the next question.

A proton with an energy of 894 eV travels perpendicular to a magnetic field and moves in a circular path with a radius of 3.60×10^{-4} m.

22. The speed of the proton is

***A.** 4.14×10^{5} m/s
B. 1.77×10^{7} m/s
C. 1.71×10^{11} m/s
D. 3.14×10^{14} m/s

Multiple-choice question 22 Most students who achieved the *acceptable standard* on the examination correctly answered this question. To obtain the correct answer, students had to first convert the energy of the proton from electron-volts to joules. The students could then substitute this value into the formula for kinetic energy and solve for the proton's speed. Alternative B, the most frequent distractor, was chosen by students who incorrectly substituted the mass of an electron into the kinetic energy equation. To obtain the result for alternative C, students found the correct value for the speed squared (v^2) of the proton but neglected to find the square root of this value. Although the value for alternative C is greater than the speed of light, 10.3% of the students chose this response.

Use your recorded answer from ***Multiple Choice 22*** *to answer* ***Numerical Response 6.****

Numerical Response

6. The strength of the magnetic field, expressed in scientific notation, is $a.bc \times 10^{d}$ T. The values of ***a, b, c,*** and ***d*** are ____, ____, ____, and ____.

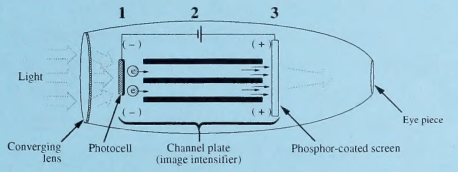
(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

*** You can receive marks for this question even if the previous question was answered incorrectly.**

Answer: 1201

Use the following information to answer the next question.

Night vision devices operate by taking available ambient light, such as starlight, and converting it into an electrical signal that is then amplified within a channel plate (image intensifier). The electrical signal is then focused on a phosphor-coated screen that emits a green image.



33. Night vision devices have a built-in brightness protection circuit to protect both the device and the viewer from unexpected bright light. The circuit is activated when the

***A.** photoelectric current increases
B. photoelectric current decreases
C. kinetic energy of photoelectrons increases
D. kinetic energy of photoelectrons decreases

Numerical-response question 6 was linked to multiple-choice question 22. Students could receive credit for this question even if the previous question was answered incorrectly. The following chart shows the alternatives for multiple-choice question 22 and the corresponding correct response to numerical-response question 6.

Response to MC 22	Correct response to NR6
A	1201
B	5132
C	4966
D	9109

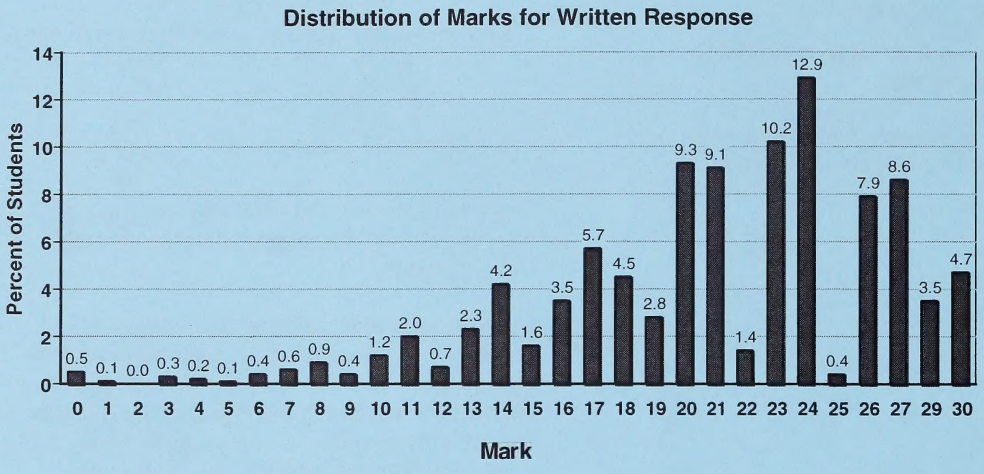
The value 1201 was always marked as correct, regardless of the student's response to multiple-choice question 22.

Most students who achieved the *standard of excellence* on the examination correctly answered this question. In order to obtain the correct answer, students had to identify that the centripetal motion of the proton was produced by a magnetic force. Only 8.6% of the students who did not achieve the acceptable standard on the examination answered this question correctly. Of this group, 23.0% of the students did not respond to the question. These results may suggest that students who do not achieve the acceptable standard lack a strategy for using the recorded answer of a previous question to answer a linked question.

Multiple-choice question 33 Most students who achieved the *acceptable standard* on the examination answered this question correctly. In order to obtain the correct answer, students had to know that the photoelectric current is proportional to the number of photons incident on the photoelectric surface. Thus, a sudden bright light incident on this surface would produce an increase in the photoelectric current. Alternative C was the most frequent distractor chosen by students. These students likely assumed that the kinetic energy of the photoelectrons was proportional to the brightness of the light, rather than to the frequency of the incident light.

Written-Response Questions

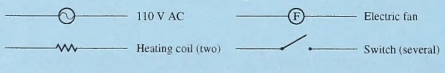
The graph below shows the percentage of students achieving various marks on the written-response questions. The maximum mark obtainable was 30. Of the students who wrote the examination, 0.5% received no marks for the written-response questions, 86.0% received 15 marks or more (*acceptable standard*), and 37.9% received 24 marks or more (*standard of excellence*) out of 30.



Use the following information to answer the next question.

You have the following components: an electric fan, two heating coils, several switches, and connecting wires. These components are to be used to construct a hair dryer.

Schematics of Hair Dryer Components



The design requirements for your hair dryer are that the fan is always on when the hair dryer is on and that it has two heat settings: high and low.

Written Response – 15%

1.

- Draw a schematic diagram of a hair dryer circuit that meets the design requirements.
- Based on the circuit diagram you have drawn, analyze the operation of the hair dryer. In your response, explain how the switch settings and their locations in the circuit control the low and high heat settings. Also, explain why the hair dryer should be designed so that the fan is on whenever the hair dryer is on.

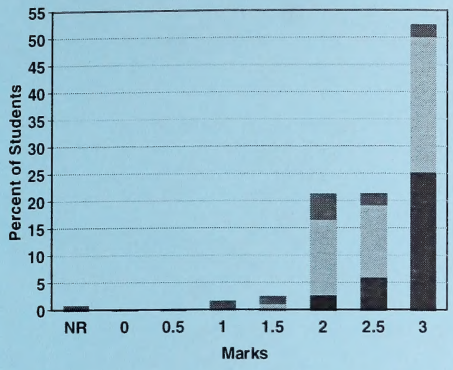
Note: Marks will be awarded for the physics principles used in your response and for the effective communication of your response

Results for **written-response question 1** indicate that the majority of students demonstrated a good understanding of schematic diagrams, the operation of a hair dryer circuit, and the function of the fan in a hair dryer.

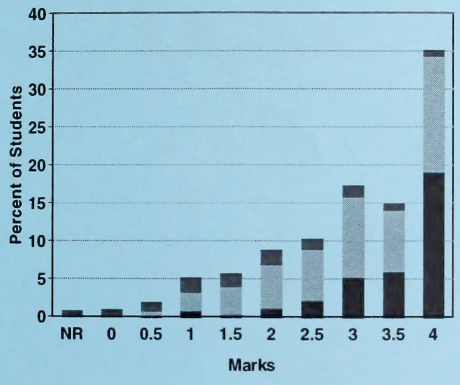
Students demonstrated a good understanding of schematic diagrams and of how series and parallel connections can be used in circuit construction. Some students encountered difficulties in drawing a schematic diagram. These students often attempted to draw circuit diagrams that conformed to the shape of a hair dryer and included design features such as the plastic case. This created unnecessary complications for these students.

Many students drew circuit diagrams that contained a "short." A short is a wire without a resistor or load, placed in parallel across the circuit. When this short is placed in parallel across other resistive branches, essentially all the current passes through the short, and there is no current in the other parallel branches.

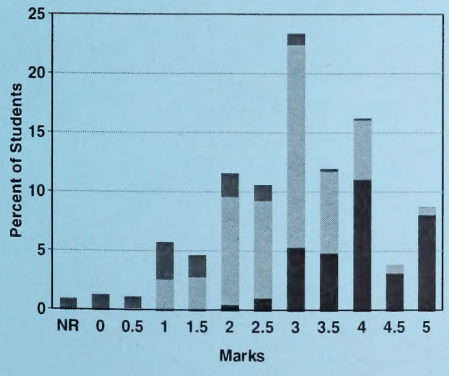
Distribution of Marks for Question 1 - Scale 1



Distribution of Marks for Question 1 - Scale 2



Distribution of Marks for Question 2



Below Standard on the Examination

Acceptable but not Standard of Excellence on the Examination

Standard of Excellence on the Examination

Among misconceptions students had about schematic diagrams and circuit operations were the following three.

- Since AC current moves in both directions, a switch is required before and after a heating coil.
- A DC power supply is required in addition to the AC power supply.
- Electrons flow in a wire until stopped by an open switch even if the path is not a continuous closed loop.

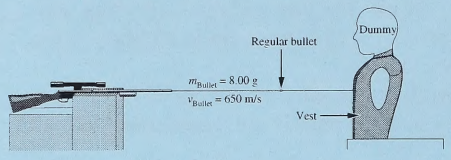
Students' attention should be drawn to the note below the question: "Marks will be awarded for the physics principles used in your response and for the effective communication of your response." Many students stated the effect of opening and closing switches on the operation of their circuits but then failed to explain, using physics principles, how the switch settings and their locations in the circuit control the heat settings.

Students demonstrated a good understanding of the functions of the fan to protect the circuit and hair dryer from excess heat and to move hot air to the user's hair.

The four major concepts addressed in **written-response question 2** were energy, impulse, momentum, and vectors. Although students continue to have difficulty solving two-dimensional momentum problems, most attempted to address all four major concepts. Most students correctly calculated the kinetic energies of the regular and the armour-piercing bullets; however, many did not quantitatively compare these energies. The most acceptable way of comparing these energies is to find the ratio of their values. Many students had difficulty calculating the energy released by the explosion. The concept of efficiency is important when dealing with STS connections and real-life contexts. Students should be reminded that in Science 10, they learned that efficiency is the ratio of the output energy to the input energy.

Use the following information to answer the next question.

Several Canadian companies are redesigning and testing bulletproof vests. One company does a test that involves firing a target rifle at a crash test dummy wearing a vest.



The company is testing the vests with both regular bullets and armour-piercing bullets. The armour-piercing bullet travels 1.20 times faster and has 1.20 times the mass of the regular bullet shown above.

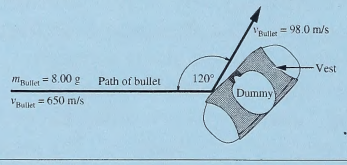
Written Response – 15%

2.

- Quantitatively compare the kinetic energy of the armour-piercing bullet with the kinetic energy of the regular bullet.
- How much energy is released by the explosion of the gunpowder if the transfer of energy from the explosion to the regular bullet is 90.0% efficient?
- The regular bullet is in the rifle barrel for 1.42×10^{-3} s. What is the average force exerted on the regular bullet by the expanding gases?

Use this additional information to answer the next part of the question.

A second test performed by the company has the regular bullet strike the vest at a glancing angle. The mass of the vest and the dummy is 56.0 kg. The bullet–vest collision is inelastic.



- Determine the resultant **speed** of the vest and the dummy following the glancing collision shown above.

Clearly communicate your understanding of the physics principles that you are using to solve this question. You may communicate this understanding mathematically, graphically, and/or with written statements.

Most students correctly calculated the average force exerted on the regular bullet either by using the equation for impulse or by using kinematics and Newton's Second Law of Motion.

Some students were confused by the statement "The bullet–vest collision is inelastic." These students believed that this meant that the bullet became imbedded in the vest: a "hit-and-stick collision." The two approved textbooks for Physics 30 define an elastic collision as a collision that conserves both momentum and kinetic energy, whereas, an inelastic collision conserves momentum but not kinetic energy. Neither the approved textbooks, nor the *Program of Studies*, has a separate term to describe a "hit-and-stick" collision.

Students recognized that the collision was two-dimensional, but many students failed to resolve the horizontal and vertical components of the momentum vectors. Vector analysis continues to be a difficult skill for Physics 30 students.

For further information, contact Bob Shaw bshaw@edc.gov.ab.ca, Laura Pankratz lpankratz@edc.gov.ab.ca, or Corinne McCabe cmccabe@edc.gov.ab.ca at the Student Evaluation Branch at (780) 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.